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The Minerals of Broadway

New York City

By JAMES G. MANCHESTER

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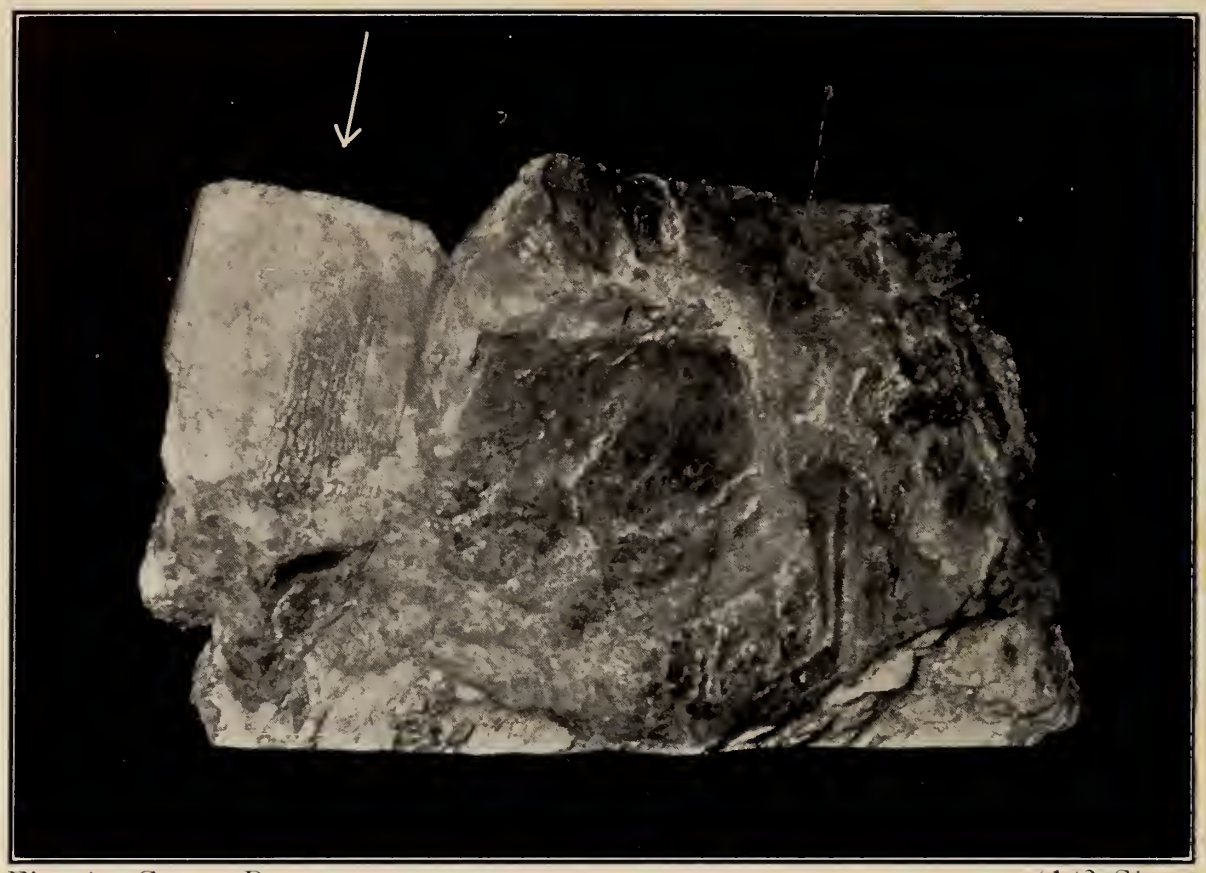

Fig. A. Green Beryl. (1/2 Size.)

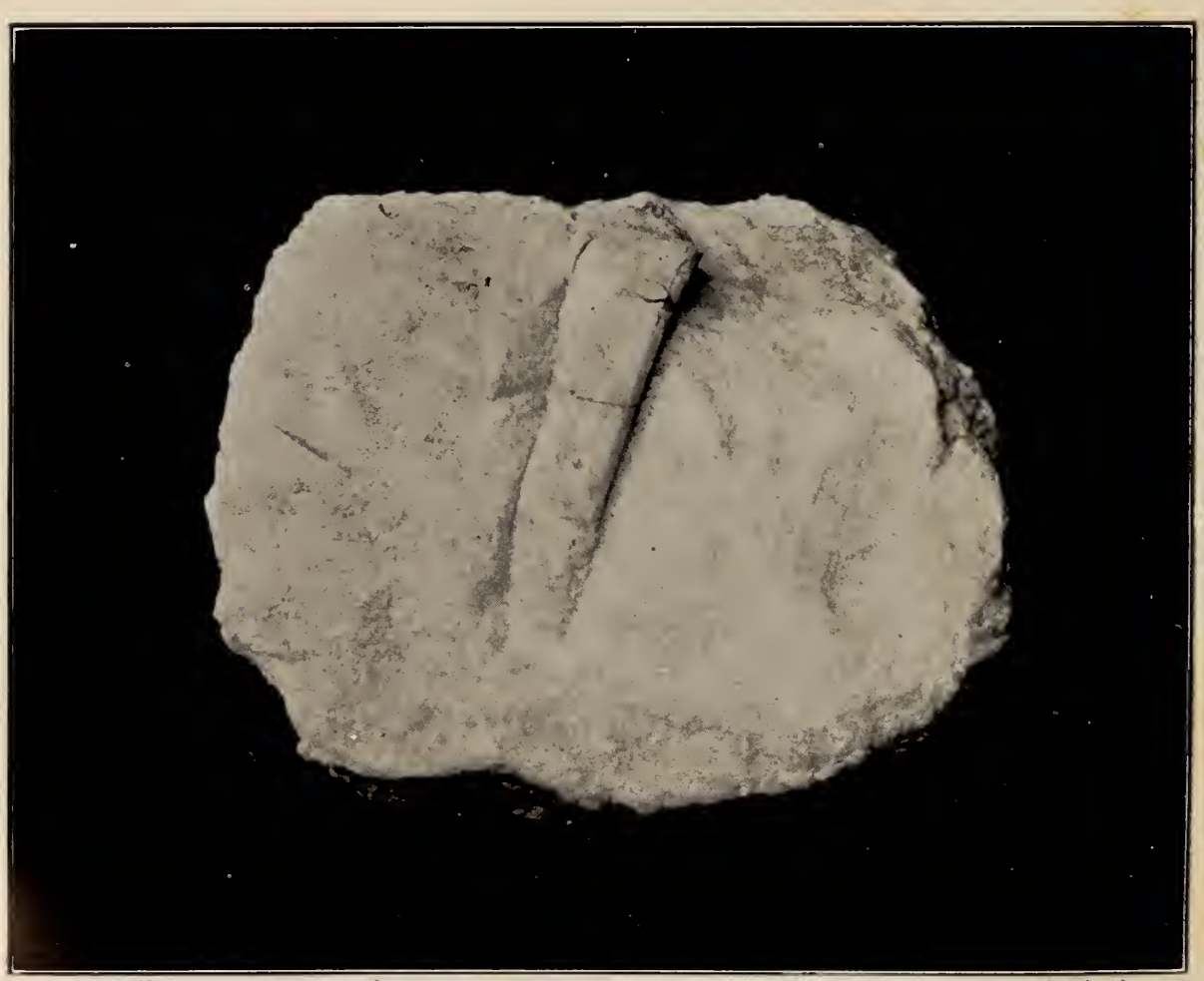

Fig. B. Pyroxene, var Malacolite. (3/4 Size.)

BULLETIN

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VOL. I MAY, 1914 No. 3

THE MINERALS OF BROADWAY, NEW YORK CITY.

BY JAMES G. MANCHESTER.

Read at the regular meeting of the New York Mineralogical Club at the American Museum of Natural History, May 14, 1913. Illustrated with lantern slides and specimens.

Broadway, stretching the full length of Manhattan Island, a distance of about thirteen miles, has been called the greatest street in the world. Its association with the ancient history of the city, its present activities in business and amusement enterprises, its "Great White Way," the skyscrapers at its southerly end and the miles of apartment houses at its northerly end, all help to make it the most talked of street in the world.

The trail of Broadway over the island begins at Bowling Green and runs in a straight line to Tenth Street, where it commences to bear off to the west, crossing Fifth, Sixth and Seventh Avenues before it reaches Fifty-ninth Street, there crossing Eighth Avenue. From this point to the north it was formerly known as the Boulevard. Broadway is the only old street in this part of the city, and makes a break in the monotonous regularity of the rectangular street plan. It continues its westward trend until West End, or Eleventh Avenue, is reached at 107th Street, where it again assumes a straight course to 170th Street. From here it takes up the old Kingsbridge Road to the end of the island at Spuyten Duyvil Creek.

Broadway has been a field for active mineral collectors for years. The many excavations in the rocks bordering upon that highway have produced minerals of unusual rarity and beauty. It is safe to say that no other public thoroughfare can equal it in the variety of minerals found along its borders.

Its rock formation is of metamorphic origin—that is, upon the original bed or foundation of the Island various sediments were deposited which were later upturned and contorted, through the agencies of pressure, crust movement and chemical action; during this upturning there was more or less heat, either from the earth's interior or from the friction produced by vast movements, and we have an island of rock known as gneiss, or schist, named Manhattan schist by local geologists. As these deposits were upturned, seams and fissures were left which were later filled with the minerals, quartz, mica, feldspar, etc., making what are known as granite or pegmatic veins or dikes. It is these veins or dikes where the various minerals have been crystallized that are the searching points for the collector.

The lower end of Broadway from Twenty-third Street south, is underlaid by the same kind of rock as is found in the upper end, but is covered with clay, sand and gravel of varying depths. Even before this section of the island was covered with buildings the opportunity for collecting minerals was very remote and confined to boulders transported from localities to the north and west.

A glance at the sketch outlining the rock basement of Broadway from the Battery to Thirty-third Street, drawn by William Herbert Hobbs,[1] shows the impossibility of collecting minerals in this section of Broadway with such a depth of sand and gravel covering the bed rock, in some places as much as 183 feet, which is the case at Duane Street. The rock cores of drills used in making tests for foundations are the only specimens procurable, and these are good only for geological study.

At University and Washington Heights and at other points

[1] United States Geological Survey, Bull. 270.

to the north, where the rock rises above or is just below the surface, opportunity is given the collector to search for minerals.

The crystalline limestones extending from Vermont to North Carolina come to the surface at the extreme northerly end of the Island and Broadway cuts through this deposit. The outcropping of this limestone is quite noticeable to the traveler in the Broadway subway, for soon after the train emerges from the tunnel at Fort George and comes out into the open at Dyckman Street, the passenger's eye is attracted by the glistening crystalline limestone to the left of the track. This locality, known as Inwood Valley, has produced some fine minerals, but the field of research is rapidly being curtailed by the big apartment structures.

The rocks and minerals of Manhattan Island have been written about for nearly a hundred years, or to be more exact, the first record we have of New York City as a mineral locality is a list of minerals published in the *Mineralogical Journal* in the year 1814. In 1825 "A Catalogue of American Minerals" was published by Samuel Robinson, M.D., and the minerals of New York County were prominently mentioned. In 1865 Dr. H. Credner, the German geologist, thought the rocks hereabouts to be of so much interest that he published in Germany a paper "On the Geology of the Vicinity of New York City."

These writers have been followed by many others, among them Berkey, Cozzens, Dana, Gale, Gratacap, Hobbs, Julien, Kemp, Levison, Merrill, Moses, Newbury, Newland, Russell, Stevens and Whitlock. Then again we have had the splendid results of such investigators and field workers as Ashby, Bailey, Braun, Camp, Chamberlin, Deems, Friedrich, Hawkins, Hidden, Kunz, Martin, Niven, Schernikow, Stanton, and many others who are members of this Club.

The New York Mineralogical Club has been in existence for twenty-seven years, and was organized for the purpose of developing and maintaining an interest in the minerals of Manhattan Island. During this time many papers have been read and

discussions held, but with the exception of a few scattered regions in the Washington Heights and Fort George sections of the island, they were mostly relating to localities south of 135th Street, where building activity was formerly most prevalent. The activity in building operations on the west side of the Island above 135th Street, resulting from the construction of

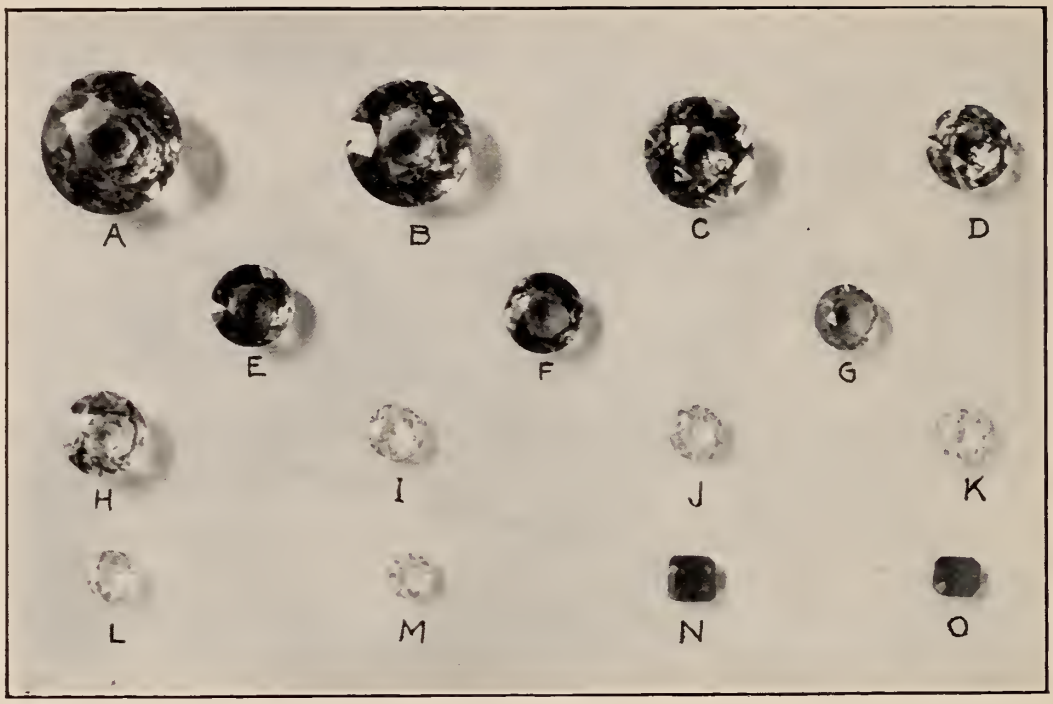

Fig. 1. Semi-Precious Stones. (Actual Size)

Cut from material found in the rocks of Broadway.

A-G, Smoky Quartz.
H-K, Aquamarine Beryl.
L-M, Golden Beryl.
N-O, Brown Tourmaline.

the Broadway subway, has recently opened up new localities for those interested in the study of mineralogy in the field.

The collecting within the last few years of much interesting material, which came under my own observation, was thought to be of sufficient importance to be recorded in the proceedings of this Club, thereby putting into permanent shape additional data relating to the mineralogical history of the Island.

It has been my good fortune to have resided in that section of Manhattan Island known as Washington Heights, where considerable excavation has been in progress. While the excavating required for the erection of buildings is only superficial,

and does not go deep into the bed rock, nevertheless, the field collector who is systematic in his work will be fully repaid for his labor. The rapidity with which the rock is removed after blasting makes it difficult for the material to be properly examined and no doubt many fine specimens are lost.

The subject of this paper has made it necessary to rely upon several publications for data relating to minerals collected years ago in that section of Broadway lying south of West 135th Street. The publications referred to are the "Geology of the City of New York," by L. P. Gratacap, A.M.; "The Minerals of New York County," by B. B. Chamberlin," and the New York State Museum Bulletin No. 70, "List of New York Mineral Localities," by H. P. Whitlock, C.E. The published lists of minerals collected on Manhattan Island in many instances fail to give the exact locality, and in referring to these records only those minerals that are listed as being found on Broadway, or in the block contiguous to that thoroughfare, are herein noted. For the more recent finds in the Washington Heights and Inwood section of Broadway the cross-town streets are given in order to record the exact locality (Plate II). With but few exceptions the minerals noted were found in crystallized condition.

AMPHIBOLE (Tremolite)

At 207th Street and Broadway there were found several deposits of tremolite embedded in the limestone. Tremolite is a variety of amphibole, having usually a white to gray color, and occurring in fibrous or columnar masses, with a somewhat silky lustre. It takes its name from Tremola Valley in the Alps, where this mineral was first discovered.

AMPHIBOLE (Asbestus)

Tremolite and other varieties of amphibole, except those containing much alumina, pass into fibrous varieties, the fibers of which are sometimes very long, fine, flexible, and easily separable by the fingers, and look like flax. These kinds are called

asbestus (from the Greek for incombustible). Mountain leather, a variety of asbestus in thin flexible sheets, made of interlaced fibers, was collected at the 207th Street locality.

AMPHIBOLE (Byssolite)

Byssolite, a green moss-like variety of amphibole, was found years ago at Broadway and Fifty-fifth Street, associated with epidote.

APATITE

Dark green crystals of apatite have been collected at 135th, 162nd and 164th Streets and Broadway. Apatite crystals are easily broken in being taken out of the Manhattan rocks, and for this reason they adorn but few cabinets.

Apatite means in Greek, "to deceive," as this mineral is often mistaken for other species.

BERYL

Crystals of green and yellow beryl have been found on Broadway from time to time. Mr. Gilman S. Stanton reports specimens of green beryl, collected at the Sixty-fifth Street locality, the most recent discovery of this mineral being made in several excavations along Broadway from 150th Street to 163rd Street. At 157th Street the rock was penetrated by a pegmatite dike and several large green beryl crystals were taken out, one specimen having a fine basal termination (Plate I, Fig. A). Another specimen contained a section of fine transparent light green beryl of the aquamarine variety. A visit to the lapidary resulted in the acquisition of several gem aquamarines (Fig. 1, H to K); the

Fig. 2. Golden Beryl.
(Magnified 2½ diameters.)

largest stone, weighing about 1½ carats, is of a pale green color and is an unusually handsome stone, both in color and in lustre, making it without doubt the finest gem stone yet found in the Manhattan rocks. Years ago the dark green beryls found on the Island were in mistake called emeralds, which are a variety of beryl, and the early writers on mineralogy listed Manhattan Island as one of the three localities in the United States where emeralds were found.[1]

During the excavating for an apartment building just west of the Chapel of the Intercession, Broadway and 158th Street, a single crystal of golden beryl was taken out. The crystal is transparent and gems of a good color have been cut from it (Fig. 1, L-M).

A unique and rather interesting specimen found at Broadway and 207th Street, is a light colored yellow beryl crystal penetrating a crystal of calcite (Fig. 2). The associated minerals are quartz and muscovite.

CALCITE

Although calcite crystals are the commonest of all kinds of crystals and have been noted in hundreds of different forms, they are quite rare on Manhattan Island. One might naturally expect many crystals to be in evidence in the Inwood limestone as they have been found quite plentifully in the limestone in the Bronx. In the collection of New York City minerals in the Hall of Mineralogy at the American Museum of Natural History, there is but one specimen of calcite exhibited, and that a simple rhombohedron cleavage. During the winter of 1912-1913, at 207th Street and Broadway, there were found in the limestone several quite transparent calcite crystals of a brownish color. These crystals, having been subjected to more or less weathering, are slightly altered, but there is sufficient evidence to show that at one time they had been crystals of the scalenohedron habit. At 218th Street and Broadway several groups of very small transparent crystals of calcite were found.

[1] The Minerals of New York County, by B. B. Chamberlin.

CHALCOPYRITE AND MALACHITE

Of the copper ores Broadway has furnished several specimens of chalcopyrite crystals found in the Manhattan schist at 170th Street. Thin flakes of malachite were also noted at this same locality, doubtless a derivative from the chalcopyrite.

CHRYSOBERYL

In the block bounded by Broadway, St. Nicholas Avenue, 164th and 165th Streets, there was found a small crystal of chrysoberyl embedded in Manhattan schist. The crystal is transparent and of gem quality. It is exceedingly interesting from the crystallographer's point of view in that two new planes for the chrysoberyl were noted by H. P. Whitlock, State Mineralogist, and described[1] by him as follows:

"The crystal, which is shown in Fig. 3, measures 5 mm by 8 mm, is light yellowish green in color and is so embedded that about one-half of the prismatic zone is exposed. On the partly exposed end traces of terminating planes were noted, but these were so rough and indefinite that no terminating forms could be identified. Measurements in the prismatic zone showed the presence of the following forms: $a(100)$, $b(010)$, $t^*(11.3.0)$, $m(110)$, $s(120)$, $g^*(370)$ and $r(130)$. Of these, t and g are new to the species. Owing to the position of the matrix surrounding the crystal, only one face of each of these new forms could be observed. The planes were narrow and t yielded a fair, and g a rather poor reflection of the goniometer signal. The forms were identified from the following measurements which in every case except that of m corresponded to a single observation; m furnished two readings:

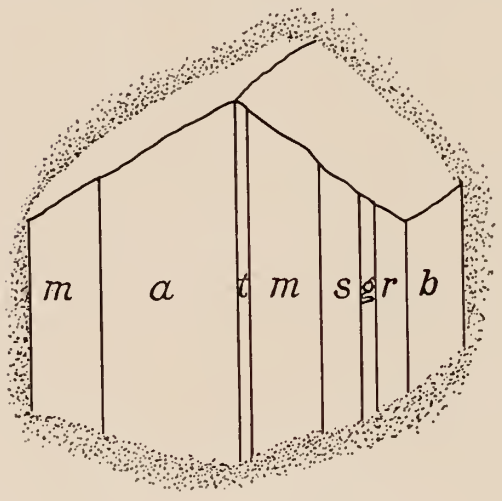

Fig. 3. Chrysoberyl.

[1] N. Y. State Museum, Bull. 158, 1911; 185.

LETTER	ANGLE	MEASURED		CALCULATED	
a : *t*	100 : 11.3.0	7°	21′	7°	18½′
: *m*	: 110	25	12	25	10½
: *s*	: 120	43	17	43	13½
: *g*	: 370	47	15	47	39½
: *r*	: 130	54	44	54	39½
: *b*	: 010	90	2	90	0

DUMORTIERITE

Mr. Frederick Braun reports dumortierite, a basic aluminium silicate, as having been found at 171st Street and the Boulevard (Broadway).[1] This is an unusual mineral and is found in few localities. When first discovered on Manhattan Island it was thought to be indicolite, the blue variety of tourmaline, but it was later identified as dumortierite by E. S. Dana. It has been sparingly found on the Island in acicular crystals of a beautiful ultramarine blue color, aggregated in fasces or tufts resembling clippings of hair.[2] The mineral occurs almost entirely in the feldspar, and rarely in distinct crystals.

EPIDOTE

While very fine specimens of epidote have been found on the Island thus far the writer has obtained but one specimen, and that a very small one, from 136th Street and Broadway, a block away from the famous epidote locality no longer available at Amsterdam Avenue and 135th Street. The crystal is sharp with brilliantly reflecting faces; it has been broken and the intervening space filled with quartz. Epidote has also been found on Broadway at Fifty-fifth and 138th Streets.

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[1] Dumortierite, by W. T. Schaller, U. S. Geo. Survey, Bull. 262 : 91.

[2] The Minerals of New York County, by B. B. Chamberlin.

FLUORITE

Mr. H. S. Williams, a member of this Club, found a large greenish block of fluorite (six inches by three) on Broadway, between Fifty-third and Fifty-fourth Streets, during the excavating for the subway, and it is probably the only specimen of this mineral yet found on Manhattan Island.

GARNET

Garnets are quite a common mineral on the Island. They are usually opaque and of a dark red color and rarely, if ever, of a gem quality. Fine crystals of this mineral have been found along Broadway from 157th to 168th Streets (Fig. 4). A

Fig. 4. GARNET. (2/3 Size.)

deposit of small garnets in a cream-colored schist was found many years ago at Broadway and Twenty-third Street. During the excavating for the new McAlpin Hotel, Broadway and Thirty-fourth Street, the newspapers reported a find of garnets by the workmen. The rock core of a test drill used on the site

of the old Mutual Life Building, at the southeast corner of Broadway and Liberty Street, showed the presence of garnets in the schist at a point 73 feet below the curb line. The best find of garnets on the Island was made in 1888 by Gilman S. Stanton, then a young student in mineralogy, who discovered a vein at Broadway and Sixty-fifth Street. Here is Stanton's description[1] written at that time:

"This vein contained a remarkable quantity of interesting, beautiful and exceedingly perfect crystals of garnet. The vein, which was of coarse granite, cut a light colored gneiss and averaged some three feet in width. The mica of the granite was muscovite, often in imperfect crystals seven inches across and as much in thickness. The smoky quartz and orthoclase oc-

Fig. 5. GARNETS—Stanton Collection. (1/3 Size.)

curred in correspondingly large masses, the orthoclase sometimes being crystallized. Some of the groups of garnets are very beautiful (Fig. 5). One consisting of fifty-nine crystals about three-eighths of an inch in diameter, on a part of an orthoclase crystal ten by eight by four inches. An interesting feature of the garnets was their crystalline form. They were the com-

[1] Trans. N. Y. Academy of Sciences, Jan. 5, 1891, Vol. X:50.

bination of the trapezohedron truncating the rhombic dodecahedron, the faces of each being about equally prominent."

This deposit was afterwards "discovered" by a dealer in minerals, who, in a few hours with men and tools, took out all the available supply of garnets, which netted him a handsome profit. This is probably the only mineral deposit on the Island that has been worked from a commercial standpoint.

The most interesting crystal of garnet found on Manhattan Island is owned by Dr. George F. Kunz, and at present forms a part of his loan exhibit of local minerals in the New York Mineralogical Club Collection at the American Museum of Natural History. The following is a description[1] of this garnet written by Dr. Kunz:

"The finest large garnet crystal ever found, perhaps, in the United States, was discovered, strange though it may seem, in the midst of the solidly-built portion of New York City. It was brought to light by a laborer excavating for a sewer in West Thirty-fifth Street, between Broadway and Seventh Avenue, in August, 1885. A quartzite vein, traversing the gneiss, contained the crystal.

Fig. 6. GARNET—Kunz Collection. (1/3 Size.)

"In form the crystal is a combination of the 2-2 tetragonal trisoctahedron (trapezohedron), the predominating form, and I—dodecahedron, and 3-3/2 hexoctahedron.

"It weighs nine pounds ten ounces (4.4 kilos), and measures fifteen cm. (six inches) in its greatest diameter, and six cm. on its largest trapezohedral face.

"Twenty of the trapezohedral faces of the crystal are perfect,

[1] Trans. N. Y. Academy of Sciences, May 31. 1886, Vol. V:265.

while the remaining faces were obliterated in the formation of the crystal by pressure against the quartzite matrix.

"On the surface the color is a reddish-brown, with an occasional small patch of what is apparently chlorite, which greatly enhances its beauty. On a fractured surface, however, the color is a light almandine and the material in the interior of the crystal is found to be very compact."

The laborer who dug out this specimen took it to a store in West Thirty-fifth Street and for several months it was used as a door-stop. Someone suggested that it was a garnet and a valuable gem, and it eventually came into the possession of the present owner. While it is not of gem quality nevertheless it is a remarkable specimen. The accompanying illustration (Fig. 6), from an engraving by Mr. B. B. Chamberlin, is a faithful representation of this garnet. When we consider the difficulty in removing garnet crystals without fracture from the Manhattan rocks we cannot help but admire this specimen, almost perfect, with its sharp angles and smooth faces.

GRAPHITE

Graphite is quite a rare mineral on Manhattan Island and has been found in but few localities. During the winter of 1912-1913 graphite as scale-like inclusions in a crystal of quartz was found at 207th Street and Broadway.

GYPSUM

With the presence of pyrite and pyrrhotite in the limestone at the upper end of Broadway it is quite natural that gypsum should be in evidence. When pyrite or pyrrhotite is in the weathering belt oxidation takes place and the action of the resulting sulphuric acid on the limestone forms gypsum. Several specimens of gypsum in the shape of a network of crystals deposited on the gneiss were found at 207th and 218th Streets and Broadway.

KAOLIN

Kaolin, a mineral resulting from the decomposition of feldspar, was reported by Mr. F. A. Camp as having been taken out at a point 56 feet below the curb line on West 32nd Street, between Broadway and Fifth Avenue.[1] This mineral has also been found at Broadway and 158th Street.

MAGNETITE

During the Summer of 1912, 176th Street was worked to grade. In blasting away the rock a well developed vein of magnetite in the Manhattan schist was brought to view a few feet east of Broadway. Large massive specimens of the mineral were removed. A peculiarity of this deposit was that the magnetite showed the cleavage lines quite plainly, and with the aid of a light hammer and chisel the mineral could be trimmed so as to produce unusually fine pseudo-crystals (Fig. 7). Magnetite also has been found at 164th Street and Broadway. Chamberlin reports magnetite as being found in solid black cubical blocks at 170th Street and Eleventh Avenue, now Broadway at that point.

Fig. 7. MAGNETITE. (5/6 Size.)

MANGANESE OXIDES

(Wad, Bog-manganese, Psilomelane, etc.)

Mr. Yeshilian has taken some pains to examine black, burnt-

[1] Geology of the City of New York, by L. P. GRATACAP, A.M., 1909:137.

looking exposures of the schist, especially on Washington Heights at 146th Street, between Broadway and Amsterdam Avenue. These he found to be unquestionably accumulations and crusts of manganese oxides.[1]

MARCASITE

Marcasite, a sulphide of iron, in the form of slender capillary crystals interwoven like a wad of hair, was collected at Broadway and 207th Street. The specimen is very small, and was only brought to view by dissolving out a calcite vein in the schist. In this same vein were minute crystals of quartz, muscovite and rutile.

MICA

A common mineral upon the Island and one that is most noticeable is mica. Mica is one of the principal rock-forming minerals and is readily distinguished by its glistening scalelike coating upon the rocks. Mica is not only of great importance as a rock-forming mineral but owing to its easy cleavage into thin plates or leaves with smooth and bright surfaces, often transparent, highly resistant to electricity, and to both high temperatures and sudden changes of temperature, it also finds many applications in the industrial arts. On account of its possession of such properties it has long been used for windows of stoves and lanterns and the chimneys of lamps and gas burners. A short time ago the writer found a stove-dealer on Amsterdam Avenue at work splitting books of mica and cutting the sheets into sizes suitable for the windows of stove doors. Upon inquiry it was found that he had secured a supply of the material from an excavation on Broadway.

Of the micas the most common variety met with is muscovite, a potassium mica. The mineral gets its name from the fact that thin transparent sheets were formerly used in Russia for window panes and was known as "Muscovy glass." The

[1] Geology of the City of New York, by L. P. Gratacap, A.M., 1909:138.

name muscovite was given it by J. D. Dana in 1850. Masses of small crystals of muscovite have been taken out at Sixty-third Street and Broadway. Fine crystals have been collected in excavations from 162nd to 170th Streets on Broadway (Fig. 8). Pale green transparent crystals were found in the Inwood limestone at 207th and 218th Streets. At these same localities mica has been found containing many inclusions of other minerals, such as green beryl, flattened garnets, finely terminated

Fig. 8. Muscovite. (1/3 Size.)

black tourmaline, magnetite in crystals and in dendritic forms, crystals of pyrite, pyrrhotite, goethite, rutile, and films of quartz. The study of this feature of the mica alone is an almost endless task and is receiving serious attention on the part of several members of this Club, and we may look for some interesting data in the near future.

A variety of mica known as phlogopite, or magnesia mica, contains the elements magnesium and fluorine in addition to those present in muscovite. It much resembles muscovite in appearance, but is often of a yellowish or brownish color. It differs also in its mode of occurrence, being usually found in crystalline limestones. Phlogopite is found in small scalelike deposits in the limestones at the upper end of Broadway, and

is observed in thin bandlike aggregates running through the limestone, often associated with pyrite.

Another variety of mica found at 162nd Street and Broadway is biotite. This differs from phlogopite in containing some iron in addition to magnesium; it is consequently darker in color, being deep brown or black. The mineral takes its name from the celebrated French physicist and astronomer, J. B. Biot.

MICROLITE

Microlite, a calcium pyrotantalate, whose crystals are very small and sometimes highly modified, was found by W. E. Hidden, at Thirty-ninth Street and Broadway, in small octahedrons in oligoclase.

OLIGOCLASE

Oligoclase, a mineral of the feldspar group, has been found in many localities on the Island. Several specimens of this

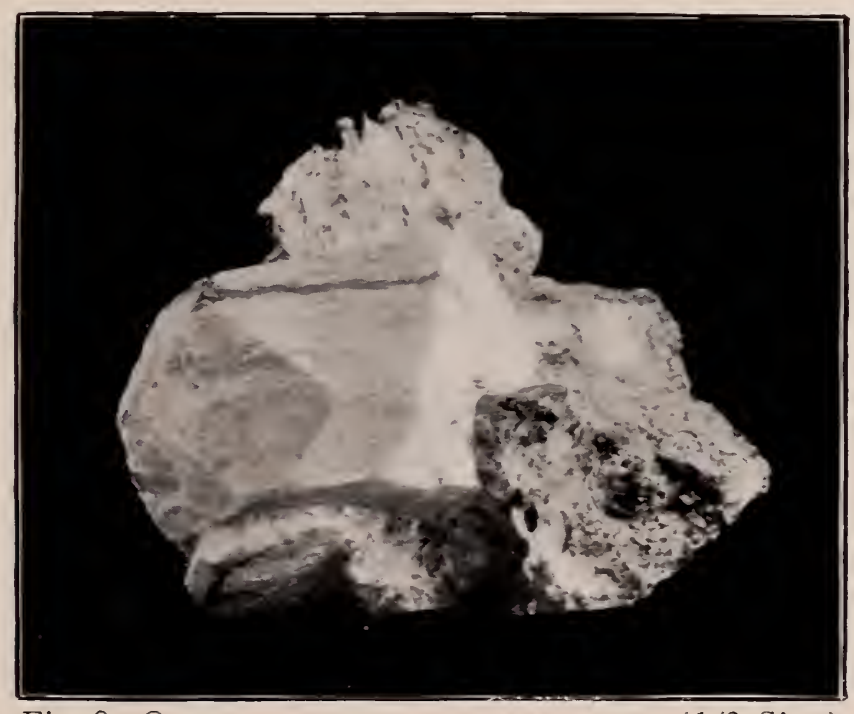

Fig. 9. OLIGOCLASE. (1/2 Size.)

mineral were taken out of the schist at Broadway and 161st Street. The largest crystal (Fig. 9) measures 2¾ inches by 1½ inches, is greenish gray in color, and is remarkably well developed for such a large crystal, the proportion of the various

planes being almost diagrammatic; the crystal is somewhat flattened parallel to the C plane in which respect it resembles those from Fine, N. Y., which are figured by Penfield in the Dana System. Crystals of this mineral were also found at 158th and 176th Streets and Broadway. Mr. F. A. Camp reports large crystals of oligoclase collected on Broadway in the Washington Heights section.

OPAL (Hyalite)

Hyalite, a variety of opal, was found by Mr. Gilman S. Stanton in the block between Sixty-fifth and Sixty-sixth Streets, just west of Broadway. The mineral was mostly botryoidal in form, coating what were probably joint surfaces of the schist. Some was vitreous and nearly transparent—the Muller's glass variety—but the thicker coatings were opaque and milky. This is the only find of opal thus far recorded for Manhattan Island.

ORTHITE

A mineral containing thorium and other rare elements is orthite, a variety of allanite, found years ago at the southeast corner of Broadway and Fifty-sixth Street. The crystals were from 2½ to 3 inches in length, of a dark reddish brown color, looking much like thin, rusty nails, often bent and twisted and set in white oligoclase, which was stained red in the vicinity of the crystals.

PYRITE

In the Inwood limestone at 207th, 218th and 225th Streets and Broadway, many crystals of pyrite have been taken out, showing such a variety of form and a brillancy of lustre that make them a welcome addition to any cabinet.

One of these crystals found at 225th Street, just west of Broadway, was sent to H. P. Whitlock for study and has been described[1] by him as follows:

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[1] N. Y. State Museum, Bull. 158, 1911:183.

"The specimen consisted of a single small crystal measuring 3 mm in diameter and developed with almost diagrammatic symmetry. The faces which are sharp and brilliant gave excellent images of the signal. This crystal, which is illustrated in Fig. 10, shows besides the forms previously recorded from the locality [Kingsbridge] the forms $d(110)$, $g(520)$, $r(650)$, $p(221)$ and $t(421)$, all of which have been frequently recorded for pyrite. The development of the zone [210. 001] is specially characteristic of this crystal, the forms occurring as follows: (210), (421), (211), (212), (213), (214), (001).

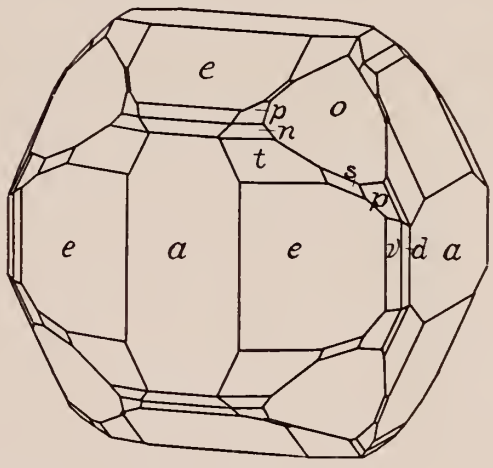

Fig. 10. Pyrite.

"The forms occurring in the zone [001. 110] are: (001), (112), (111), (221), (110).

"The forms were identified by means of their zonal positions as follows:

LETTER	ANGLE	NO.	MEASURED		CALCULATED	
Zone [100 . 110]						
$a : g$	100 : 520	2	21°	39′	21°	48′
$: e$	: 210	11	26	35	26	34
$: v$	: 650	8	39	44	39	48
Zone [210 . 001]						
$c : t$	210 : 421	8	12	$36\frac{1}{2}$	12	36
$: n$	: 211	13	24	3	24	6
$: p$	: 212	10	41	47	41	49
$: s$	: 213	6	53	19	53	18
$: t''$	: 214	6	60	$48\frac{1}{3}$	60	48
Zone [100 . 111]						
$a : n$	100 : 211	6	35	16	35	16
$: p$	: 122	5	15	$46\frac{1}{2}$	15	$47\frac{1}{2}$

At 207th Street and Broadway an unusually fine pyrite crystal of the octahedral form was taken out. The crystal is nearly one-half inch in diameter, the faces of which are beautifully etched. At this same locality massive pyrite was noted. At Thirty-second Street, near Broadway, at a depth of forty-nine feet, Mr. A. S. Coffin reports that quartzite was taken out coated with pyrite.

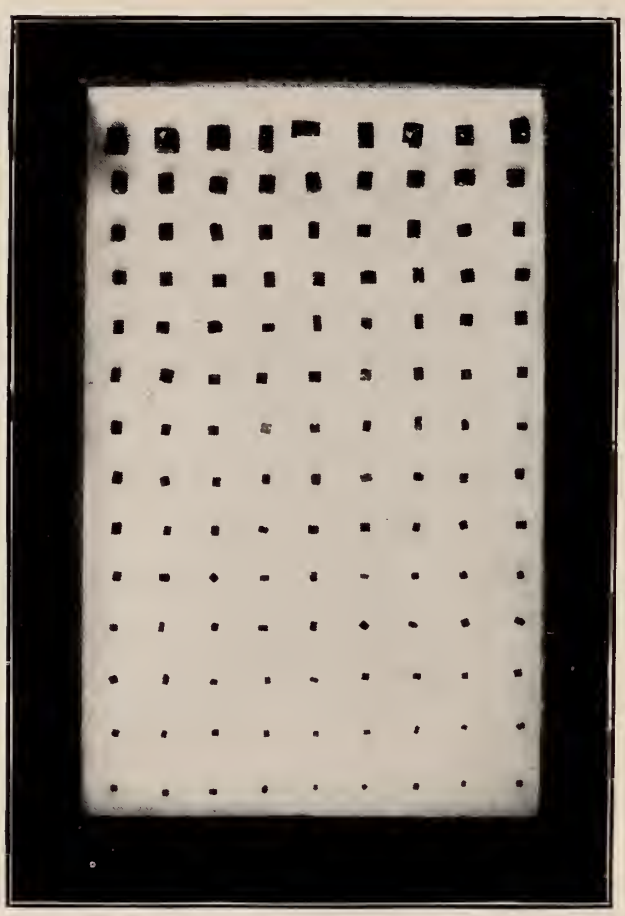

Fig. 11. Limonite Pseudomorph after Pyrite. (Actual Size.)

By the action of water containing oxygen and calcium carbonate in solution, pyrite suffers alteration; the sulphur is carried away in solution as gypsum and the iron is left behind as a ferric hydroxide (limonite) which preserves the original form of the crystals. We have thus a pseudomorph of limonite after pyrite; that is, limonite with the external form of a crystal of pyrite. Limonite pseudomorphs after pyrite were found at 204th Street, east of Broadway (Fig. 11). Mr. George E. Ashby reports limonite pseudomorphs after pyrite cubes as inclusions in mica found on Broadway at 144th and 165th Streets; also ochre pseudomorphs after pyrite at the 144th Street locality.

ORTHOCLASE (Adularia)

Several finely terminated crystals of adularia, the nearly pure potassium aluminium silicate, were found in the Inwood limestone at 207th, 218th and 225th Streets and Broadway. Adularia is a variety of orthoclase and is named after Adula, a mountain group in the Grisons Alps, where fine specimens have been found.

PYROXENE (Malacolite)

Pyroxene is essentially a normal metasilicate of calcium and magnesium, also containing iron manganese or zinc and sometimes small percentages of potassium and sodium. The many varieties are usually classified as aluminous and non-aluminous. Malacolite, usually white or pale green in color, is of the non-aluminous variety. This variety is quite common in the Inwood limestone where it is found in well developed and quite stout crystals, usually white in color (Plate I, Fig. B). The hardness of malacolite ranges from 5 to 6 and when found exposed to the weather it has outlasted the limestone in which it was enclosed and the crystals are often protruding from or lying loose on the matrix. Crystals of malacolite are often bent and fractured similar to the tourmalines. Several fine specimens were collected at the 207th Street locality. Single crystals of malacolite were found in the ploughed fields in the neighborhood of 218th Street.

PYRRHOTITE

Distinct crystals of the mineral pyrrhotite are quite rare in any locality, but at Broadway and 218th Street small perfect hexagonal crystals of a tabular habit were found. When taken out the crystals were of a bronze-yellow color and closely resembled phlogopite, a variety of mica, but upon exposure to the air the color changed to a copper-red and bluish tarnish and after other tests it developed that the mineral was pyrrhotite (Fig. 12). Massive pyrrhotite, associated with iron pyrites, was also found at 207th Street and Broadway. At 215th Street and Broadway this

Fig. 12. Pyrrhotite. (Mag. 19 dia.)

mineral was found as inclusions in mica, quartz, tourmaline and calcite crystals.

QUARTZ

Quartz is the most abundant and widely distributed of all minerals and it is quite natural therefore that it is a common constituent of the Manhattan rocks. Quartz, when perfectly pure, is quite transparent and colorless, this being the variety known as rock crystal.

Fig. 13. Quartz. (Actual Size.)

Rock crystal is frequently, though not always, found in the form of terminated crystals, having usually the shape of six-sided prisms terminated at one or both ends by pyramids. Several fine specimens of these crystals were collected at 207th and 218th Streets and Broadway (Fig. 13). Many of the crystals found at this locality were of the tapering form, some at first glance suggesting dog-tooth calcite. Chamberlin reports terminated crystals of quartz one inch in diameter and two inches long, found at the orthite locality, Broadway and Fifty-sixth Street. At 164th Street there was found a rare form of quartz crystal, known as bi-pyramidal, or double six-sided pyramid. The crystal is one-half inch in diameter and is embedded in feldspar (Fig. 14).

Crystals of quartz are usually attached at one end to the rocky matrix, but sometimes, especially when embedded in a soft matrix they may be bounded on all sides by crystal faces. At Broadway and 207th Street, a number of minute doubly terminated quartz crystals were found. These were secured by dissolving the calcite in acid and in the residue were found, with the aid of a magnifying glass, these most interesting little specimens which remind one of the loose quartz crystals that are sometimes found in the geodes from the Bad Lands. At

this same locality there were taken out several clusters of rock crystal.

Smoky quartz in small crystals was found in 218th Street in the Inwood limestone, but they do not compare with the beautiful specimens in the Kunz collection which were found during the construction of the Harlem ship canal, a few blocks north

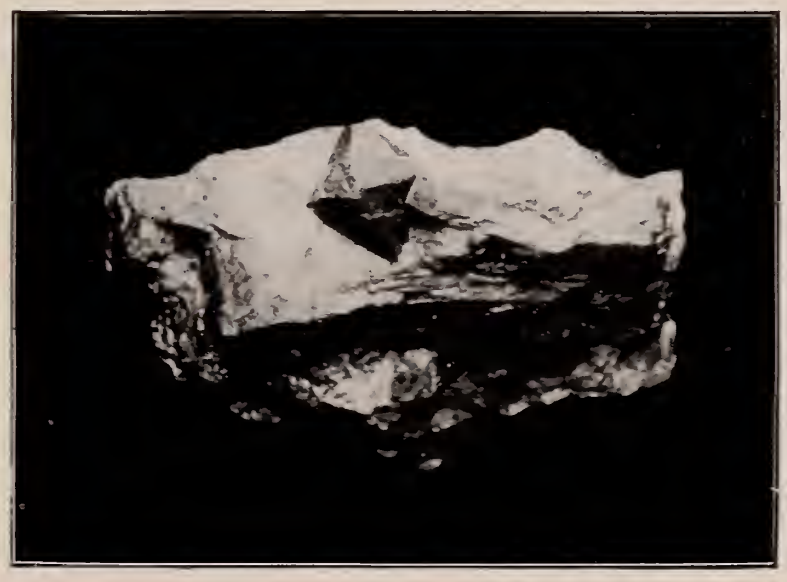

Fig. 14. Quartz. (Actual Size.)

of this locality. The massive variety of this mineral is quite common among the rocks of Manhattan. Transparent and flawless specimens from Broadway at 160th and 207th Streets have been cut into facetted stones (Fig. 1, A to G).

RIPIDOLITE (Clinochlore)

Ripidolite, a mineral of the chlorite family, was taken out of the rock forty-four feet below the curb on Thirty-second Street, between Fifth Avenue and Broadway, by A. S. Coffin.[1]

RUTILE

On Broadway, from 201st to 218th Streets, finely terminated crystals of rutile in the limestone were taken out. Hair-like

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[1] Geology of the City of New York, by L. P. Gratacap, A.M., 1909:142.

crystals of this mineral sometimes one inch or more in length, extending across the cavities in the limestone, were also noted. An unusually fine specimen from the 207th Street locality is one containing two terminated rutile crystals penetrating a terminated quartz crystal (Fig. 15). Rutile coated with prochlorite was also obtained here. Rutile associated with quartz and feldspar was found at 164th Street and Broadway. Clusters of rutile crystals in rhombic arrangement as inclusions in muscovite were collected years ago at Broadway and Fifty-fourth and Fifty-fifth Streets.

Fig. 15. Rutile. (Mag. 15 dia.)

STILBITE

Stilbite, a silicate of aluminium, calcium and sodium with some water, is a member of the zeolite group of minerals and therefore of secondary origin. Stanton reports finding stilbite at Broadway and Sixty-sixth Street in flattened radiations one and one-half inches in diameter. It has been found sparingly in other parts of the Island.

URANINITE (Pitchblende)

The radio-active mineral, uraninite, one of the sources of radium, was found years ago at Broadway and 155th Street, and is in the Kunz collection. Uraninite is also known as pitchblende and within recent years it has attracted a great deal of attention through the discovery by the late Prof. and Madame Currie, who succeeded in isolating—radium and polonium—two elements noted for their remarkable properties. The amount of radium contained in pitchblende, the richest ore of radium, is, however, extremely minute. Many tons of material have to be treated by a long series of complex chemical operations to obtain even a small amount of radium compound.

TOPAZ

A mineral new to Manhattan and furnished by Broadway, is topaz, an aluminium fluorsilicate. Only two small specimens of the massive variety were found and these in the block bounded by Broadway, St. Nicholas Avenue, 164th and 165th Streets. The determination was made by H. P. Whitlock, the State mineralogist at Albany. There is no reason why topaz should not be found in the veins or dikes of the schists of Manhattan Island.

TOURMALINE

A gem stone that is growing more popular as a jewel is the tourmaline. While it has its romances the same as other precious stones, they are comparatively modern. Broadway has

Fig. 16. Brown Tourmaline. (Actual Size.)

furnished a number of fine gem brown tourmaline crystals. Within the last year several finely terminated specimens, associated with cream colored calcite, making very attractive cabinet specimens, were collected at 201st, 207th, 218th and 225th Streets and Broadway (Figs. 16 and 17). Several of the smaller crystals have been cut for gems (Fig. 1, N-O). Small golden brown and green tourmalines were also found at these localities.

Tourmaline is one of the most complex minerals chemically.

Ruskin notes this character of the tourmaline in his "Ethics of the Dust." This book is a collection of Ruskin's lectures given at a girls' school, and were not intended as an introduction to mineralogy. Their purpose was to awaken in the minds of the young girls a vital interest in the subject of their study; these lectures also gave Ruskin an opportunity to use nature's work in crystallization as an argument against sordid living. Here is what he says of tourmaline:

Fig. 17. Gem Brown Tourmaline. (2/3 Size.)

"A little of everything; there's always flint and clay and magnesia in it; and the black is iron according to its fancy; and there's boracic acid, if you know what that is, and if you don't, I cannot tell you today, and it doesn't signify; and there's potash and soda; and on the whole, the chemistry of it is more like a mediaeval doctor's prescription than the making of a respectable mineral."

No doubt it is this complexity of composition which prevents the gem tourmaline from being produced synthetically.

Black tourmaline, while never found of a gem quality, has many interesting features and is quite common in the rocks along Broadway. Several finely terminated specimens have been collected at 161st and 162nd Streets (Fig. 18). One of the specimens here illustrated shows that after the mineral had crystallized it was broken by some eruptive disturbance, but nature saw to it that it was neatly repaired by filling in the space with quartz or other mineral (Fig. 19). This feature is quite a common occurrence, and has been observed in other minerals found on Manhattan Island, such as beryl, malacolite, epidote, and chrysoberyl, the second specimen of the latter col-

lected by Wallace Goold Levison affording a notable example.

Another feature of the tourmaline is its crystal form. The planes on a doubly terminated crystal are not alike either in number or inclination. On one end there may be three planes, on the other six or even twelve. Such a peculiarity of form is possessed by few minerals.

Fig. 18. Black Tourmaline. (Actual Size)

Crystals of tourmaline behave in a peculiar manner when they are subjected to changes of temperature. If a crystal be warmed it develops a charge of positive electricity at one of its ends, and a charge of negative electricity at the other; while if it be cooled these charges are reversed. It was in tourmaline that the phenomenon of pyroelectricity was first observed. On being heated in peat ashes its attractive power was first observed by the Dutch in the early part of the 18th century.

XENOTIME

One of the rarest and at the same time one of the most interesting minerals on Manhattan Island is the mineral xenotime. In May, 1912, at 165th Street and Broadway, while excavation was in progress for the new Audubon Theatre, one small crystal of this mineral was found. Xenotime is quite interesting in that it is composed of several rare elements, among them thorium, a radio-active chemical. In 1815, this mineral was supposed by Berzelius, the Swedish chemist, to contain a new metal, which he named thorium, before the later thorium was discov-

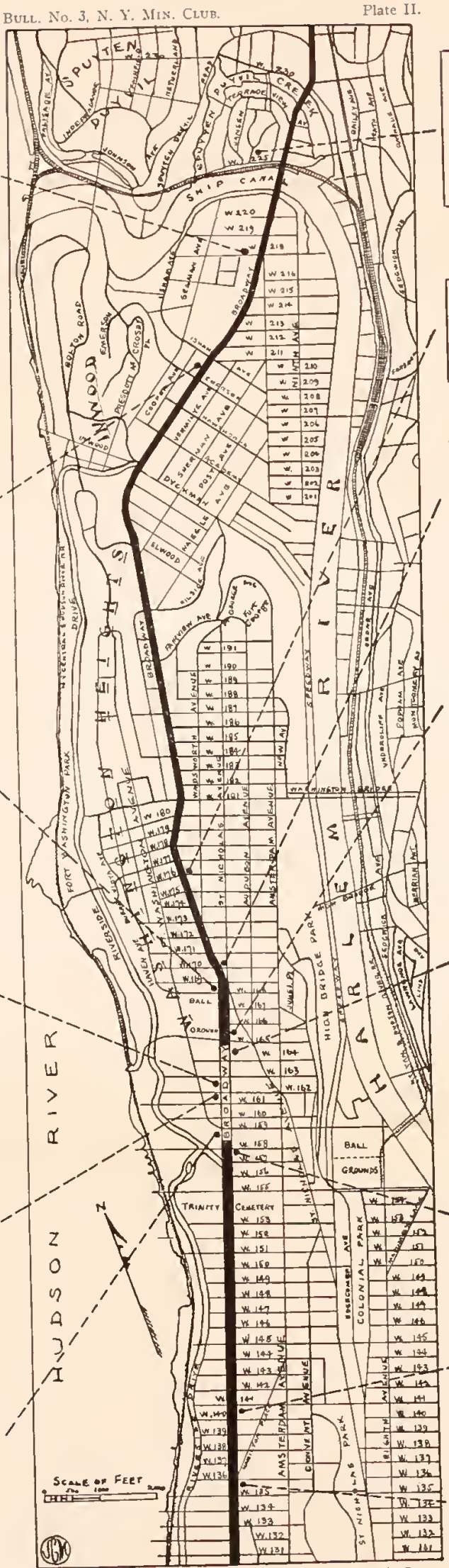
ered. The name xenotime refers to the fact that the crystals are small, not showy, and were long unnoticed.

Fig. 19. Black Tourmaline. (2/3 Size.)

IN CONCLUSION

The foregoing list is made up of 47 varieties, representing 39 distinct species of minerals, and with but few exceptions all have been noted by the writer in the rocks of Broadway. A complete list of minerals found in New York City, as reported by Chamberlin, consists of 118 varieties, or 82 species. With such a record one cannot help feeling that the collector is very fortunate indeed to be a resident in a great metropolis whose rocks are filled with such treasures of the mineral kingdom. There is still much unimproved property in the northern section of the city awaiting the excavators with their steam drills and derricks to pave the way for gigantic structures and incidentally to open up new fields for research for the lover of nature as expressed in minerals. However, if building operations keep up their present pace it will not be many years before the Island will be completely covered with buildings and the opportunity for collecting minerals will be lost forever. It therefore devolves on those who are interested to be ever alert with a view to saving a beautiful crystal or a fine gem from destruction.

AVERY CLASSICS



218th Street
CALCITE
GYPSUM
PHLOGOPITE
PYRITE
PYROXENE—MALACOLITE
PYRRHOTITE
QUARTZ—ROCK CRYSTAL
RUTILE
TOURMALINE—Brown
TOURMALINE—Green

207th Street
AMPHIBOLE—Asbestus
AMPHIBOLE—Tremolite
CALCITE
GRAPHITE
GYPSUM
MARCASITE
MUSCOVITE
ORTHOCLASE—ADULARIA
PYRITE
PYROXENE—MALACOLITE
PYRRHOTITE
QUARTZ—ROCK CRYSTAL
QUARTZ—Smoky
RUTILE
TOURMALINE—Brown

168th Street
BIOTITE
GARNET
Muscovite encl. Tourmaline
TOURMALINE—Black

162nd-163rd Streets
APATITE
BERYL—Green
GARNET
Muscovite enclosing Beryl
PYRITE
TOURMALINE—Black

161st-162nd Streets
APATITE
BIOTITE
GARNET
MUSCOVITE
OLIGOCLASE
QUARTZ—Smoky
TOURMALINE—Black

158th Street
BERYL—Golden
GARNET
KAOLIN
OLIGOCLASE
TOURMALINE—Black

225th Street
CALCITE
ORTHOCLASE—ADULARIA
PYRITE
QUARTZ—ROCK CRYSTAL
RUTILE
TOURMALINE—Brown

176th Street
MAGNETITE
OLIGOCLASE
TOURMALINE—Black

170th Street
CHALCOPYRITE
GARNET
MALACHITE
TOURMALINE—Black

165th-166th Streets
BERYL—Green
GARNET
Muscovite enclosing Pyrite
TOURMALINE—Black
XENOTIME

164th-165th Streets
APATITE
CHRYSOBERYL
GARNET
MAGNETITE
MUSCOVITE
QUARTZ—Bipyramidal
RUTILE
TOPAZ
TOURMALINE—Black

157th-158th Streets
BERYL—Aquamarine
BERYL—Green
GARNET
MUSCOVITE
PYRITE

141st Street
TOURMALINE—Black

135th-136th Streets
APATITE
EPIDOTE
GARNET
TOURMALINE—Black

THE MINERALS OF BROADWAY

(Washington Heights and Inwood Section)

Collected 1909-1913 by J. G. Manchester

The New York Mineralogical Club.

The New York Mineralogical Club was organized in October, 1886, but it was not until the eighth meeting that officers were elected. Those then chosen were George F. Kunz, Secretary; B. B. Chamberlin, Treasurer; Daniel S. Martin, Rev. J. Selden Spencer, E. A. Hutchins and George F. Kunz, Executive Committee; R. P. Whitfield and L. P. Gratacap, Curators. For several years there was no President, the host of the evening filling that office for the occasion, since the meetings were held at private houses.

The object of the Club is to develop and maintain an interest in the minerals and rocks of Manhattan Island through collecting and the study and comparison of existing collections. The principal series in existence at the time of the organization of the Club was that of the late Benjamin B. Chamberlin, who had devoted more than twenty years to the study and to the collection of minerals on Manhattan Island. After the death of Mr. Chamberlin this collection was acquired by the Club, and it is now permanently deposited in the American Museum of Natural History. With this has been deposited the George F. Kunz Collection, besides many gifts to and purchases by the Club, the whole forming a nearly complete representation of Manhattan Island minerals, which is now on exhibition in the Morgan Hall of Mineralogy.

The Club meets monthly, from October to May, at the American Museum of Natural History, for the consideration of papers upon mineralogical topics. Summer meetings in the shape of field excursions are made from time to time to nearby points of interest to the collector. Persons interested in mineralogy are invited to correspond with the Secretary regarding membership in the Club. The Club is an affiliated society of the New York Academy of Sciences.